Potassium as a mixture of chloride and citrate was administered to two children by mouth and balance studies were made. In one child with a normal serum sodium 81% of the potassium given was retained. In another child, who had a low serum sodium, only 26% was retained.

It is suggested that the electrolyte disturbances in tuberculous meningitis can be explained by the serious vomiting and prolonged low food intake in the early stages of the disease. The abnormality is not due to a deficiency of any one electrolyte, but is probably due to a combined deficit of sodium, chloride, and potassium. Ensurance of an adequate electrolyte intake may be an important contributory factor to the recovery of patients with tuberculous meningitis.

Thanks are due to Professor R. S. Illingworth for permission to study cases under his care, and to him and Professor H. A. Krebs, F.R.S., for helpful criticism in the preparation of this paper. We are indebted to the staff of the Biochemistry Laboratory, Royal Infirmary, Sheffield, for making many of the urine electrolyte investigations.

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CLINICAL AND CHEMICAL STUDIES IN HUMAN LACTATION

VII. THE EFFECT OF DIFFERENCES IN YIELD AND COMPOSITION OF MILK ON THE INFANT'S WEIGHT GAIN AND THE DURATION OF BREAST-FEEDING

BY

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Although it is recognized that there are individual differences in the yield and composition of milk, the practical effect of these differences in terms of successful breast-feeding has received almost no attention. In Sweden, Sydow (1952) investigated the relationship between the milk yield on the sixth post-partum day and the duration of breast-feeding, and found that if the sixth-day yield was under 300 ml. there was a considerably diminished chance of breast-feeding. This was an insensitive index, however, since only 25% of cases were in this low-yield group. Moreover, under "breast-feeding" were included those who were only partly breast-feeding, so that the overall figure of over 90% still breast-feeding at the end of two months, which is well in excess of any reported in this country, is difficult to interpret.

In an earlier study, Sydow (1944–5) gave an indirect indication of the effect of differences in fat content on the weight gain of the infant. Infants whose mothers donated to a milk bank milk which was stripped from the breast after feeding and therefore contained a high proportion of the fat gained less weight than those whose mothers gave milk which was removed before the feed and contained relatively little fat. The average weight gains were 765 ± 62 g. and 866 ± 42 g. a month respectively. Sydow states that the material was unsuitable for comparison, since the birth weights and ages of the infants were not taken into account, and claims no significance for the results.

Kon and Mawson (1950) found no relationship between the weight gain of the infant after the eighth week and the fat content of the milk; but the milk yield was not known and, moreover, their technique of manually expressing a single morning sample gives no accurate indication of the daily fat output, and no conclusions can be drawn from it.

Gunther and Stanier (1951) found a significant relationship between the amount by which the baby was below its birth weight on the eighth day, and the eighth-day milk volume, but none with the fat content of the milk. The interpretation of this finding is not simple, since the initial weight loss varies very widely and is not related to food intake.

The terms "lactation" and "breast-feeding" must be differentiated. Lactation is a largely automatic physiological function showing wide individual variation. Successful breast-feeding is obviously dependent in the first instance on adequate lactation, but the efficiency with which this basic capacity is exploited depends on such factors as a desire to breast-feed, social custom, intelligence, and general living conditions. It is, in many ways, a test of the capability and character of the mother.

The various circumstances which determine the difference between the number of women having successful lactation and the number who breast-feed successfully will be discussed in subsequent papers, but, in order that the significance of the figures presented here can be appreciated in their proper context, the "official" attitude towards breast-feeding in this community must be described, since the proportion of women breast-feeding can to some extent be influenced by pressure of opinion from doctors and health visitors.

In Aberdeen, preparation of the breast as recommended by Waller (1946) is not practised, although Waller's shields are sometimes used for the treatment of inverted nipples. In hospital, unless there are definite medical contraindications, or unless a woman has firmly stated her intention to bottle-feed, it is tacitly assumed that all women will breast-feed, and much care is taken and time spent encouraging the mother in the lying-in wards. Excess milk is manually expressed after feeds as a routine during the first four or five days. Engorgement of the breast is treated along orthodox lines, which include the use of oestrogens. If the puerperium is uncomplicated the mother remains in hospital for eight to ten days.

If breast-feeding is not fully established in hospital, and if the woman is anxious to persevere, she may be sent home partly bottle-feeding, but there is an increasing tendency, if lactation is obviously poor, to begin artificial feeding in hospital so that efficiency in this technique can be acquired in the security of the hospital rather than in the general turmoil of failing lactation at home. Complementary feeds are given to breast-fed infants in hospital at the ward sister's discretion. There are no rigid rules governing their use, but they are generally given after the third day if the baby is still losing weight or when, after feeding, it still appears

hungry and test weighing reveals that the intake of milk has been inadequate.

The mother is visited within 24 hours of leaving hospital by a health visitor of the maternity and child welfare service. Further visits are made, at least weekly, for the first four weeks, and less frequently thereafter, although they are made more often when necessary. Breast-feeding is encouraged, but when lactation is clearly inadequate full artificial feeding is usually agreed to be a more practical alternative than prolonged complementary feeding.

It is the general experience that the majority of women who make the change to bottle-feeding do so without consulting a health visitor. The Aberdeen general practitioner is frequently consulted, but is less enthusiastic than the health visitor about breast-feeding.

Method

All the women in this investigation were confined in the Aberdeen Maternity Hospital, and details of the progress of lactation and of the infant were recorded during the lying-in period. They included the birth weight and subsequent daily weights until discharge, and records of any complementary feeds. The weight gain in hospital was taken as the gain from the third to the seventh day, since the weight changes during the first three days are almost wholly unrelated to food intake. Information about subsequent progress until the end of the thirteenth week was obtained from the records kept by health visitors of the Maternity and Child Welfare Department. The follow-up was limited to the first three months, because mixed feeding is often introduced during the course of the fourth month, and the contribution of breast milk to the baby's total food intake is then unknown.

The duration of breast-feeding was taken to be the time, up to a maximum of 13 weeks, during which full breast-feeding was carried on. The addition of any complementary or supplementary feeding was taken to mark the end of breast-feeding.

The reason for the cessation of breast-feeding was obtained from the health visitor concerned. In many cases this rested on the mother's own story, which usually took the form of "the baby cried all night" or "he didn't seem satisfied," and all such instances, together with those where there was definite evidence of inadequate nutrition, such as falling weight, were classified together as "failure of lactation."

Of the 167 women whose milk was sampled on the seventh day of lactation 148 were followed up for 13 weeks, and in all of these information was available about the time full breast-feeding stopped and the reason (or presumed reason) for stopping. For the remaining 19, 16 of whom left Aberdeen, data were available for periods of less than 13 weeks.

Beyond the first month of life accurate weights of infants were available for only 83 who had attended child welfare clinics, and these weighings were often at irregular intervals. In order that weights at fixed intervals could be used for statistical analysis, weight curves were constructed for each infant, and the presumed weights at four weeks, eight weeks, and twelve weeks were read from the curve. Weights were recorded only while full breast-feeding was in progress, so that if, for example, breast-feeding had ceased at six weeks, only the weight at four weeks would be available from the curve. Extrapolation beyond the last recorded weight was not attempted.

The method of collection of the milk samples, and the chemical analyses, have been described in previous papers (Hytten, 1954a, I, II, III).

Results

In testing the relationship between seventh-day milk and the clinical data on breast-feeding and infant weight gain, the milk yield and the several constituents were each tested separately. Only the yield and the fat content were related to the clinical findings, and, since these are not related to each other, it seemed logical that a stronger relationship could be found by multiplying them to give the total fat output for 24 hours. In practical terms, a milk with a poor fat content might be clinically satisfactory if it were associated with a high yield, and, conversely, a high fat content might compensate for a low yield. This proved to be so, and total fat output has been used for most of the following results.

Weight Gain of the Infant in Hospital

In assessing the infant's progress in hospital, 10 cases were excluded—five because the weight was not recorded on the third day, and five because artificial feeding was used during the first week, when breast-feeding had been temporarily suspended because of sore or cracked nipples.

Fig. 1 shows, in the remaining 157 infants, the relationship between the seventh-day milk fat output and the weight gain of the infant from the third to the seventh day.

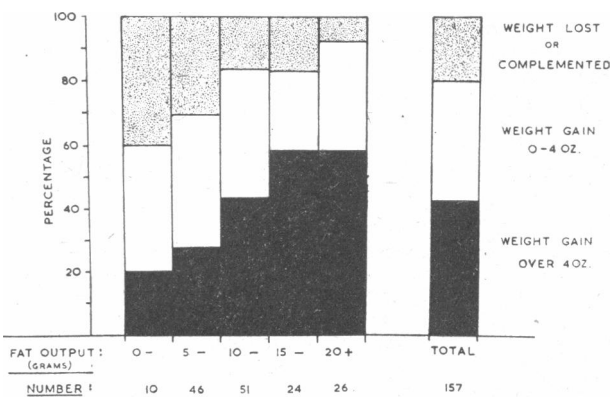

FIG. 1.—The relationship of the fat output in the seventh-day milk to the weight gain of the infant and the need for complementary feeding from the third to the seventh day.

In the group where the fat output was less than 5 g., 40% of the infants either lost weight or required complementary feeding, and only 20% gained more than 4 oz. (113 g.). With higher fat outputs the weight gains were correspondingly better, and in that group in which the fat output was 20 g. or more 58% of the infants gained more than 4 oz. and only 7.5% lost weight or required complementary feeding. There was a statistically significant difference between the amounts of fat in the milk of those infants requiring complementary feeds compared with the rest ($P<0.01$), but in the infants not having complementary feeds there was no significant correlation between the fat output and the infant's weight gain. This was partly due to the wide range of values for both weight gain and fat output and to the relatively small numbers, but there is also a contributory factor, which is best illustrated by the four cases in which the fat output was over 35 g. In this group one infant lost 2 oz. (57 g.); the other three gained only 1½, 2½, and 4 oz. (43, 71, and 113 g.), for the reason that where there was a gross excess of milk the infant had a full feed well before the breast was empty, and the remaining milk, which contained much of the fat, was expressed for the milk bank.

Weight Gain During the First Three Months

The seventh-day fat output was related to the weight gain of the infant during the first four weeks ($P<0.01$), but not at later stages.* It must be pointed out, however, that the weight gain at eight and twelve weeks refers only to

*The regression equations were:

Ounces weight gain (3rd day–4 weeks)	$=25{\cdot}2+0{\cdot}50$ (Fat output) $\pm 0{\cdot}18$ in grammes)	$-0{\cdot}05$ (3rd day $\pm 0{\cdot}08$ weight in oz.)	
Ounces weight gain (3rd day–8 weeks)	$=98{\cdot}2+0{\cdot}14$ $\pm 0{\cdot}34$	,,	$-0{\cdot}35$ $\pm 0{\cdot}16$	,,
Ounces weight gain (3rd day–12 weeks)	$=121{\cdot}4-0{\cdot}24$ $\pm 0{\cdot}61$	,,	$-0{\cdot}22$ $\pm 0{\cdot}29$	,,

those infants who were still breast-feeding at these stages, and by the eighth week the majority of infants whose mothers had a low fat output had ceased breast-feeding.

Duration of Breast-feeding

Of the 148 mothers for whom data are available up to the thirteenth week, 23 were excluded from this part of the study because breast-feeding had been discontinued for reasons clearly unrelated to the adequacy of lactation. Of these 23, 11 had cracked nipples or mastitis, 8 stopped because of vague ill-health, 2 refused to continue breast-feeding after leaving hospital, one wished to return to work, and in one case feeding was abandoned because of an acute illness of the baby.

Of the remaining 125, 64 (51.2%) stopped breast-feeding before the thirteenth week because of "failure of lactation." Fig. 2 shows the percentage of infants still being breast-fed at stages up to 13 weeks, in the five fat-output groups. In the group having the highest fat output (20 g. or more), 89% breast-fed for thirteen weeks. With lower fat outputs, correspondingly fewer women succeed in breast-feeding, and in those with the poorest fat output (less than 5 g.) only 18% breast-fed for thirteen weeks. The relationship between fat output and the duration of breast-feeding is statistically significant ($P<0.01$).

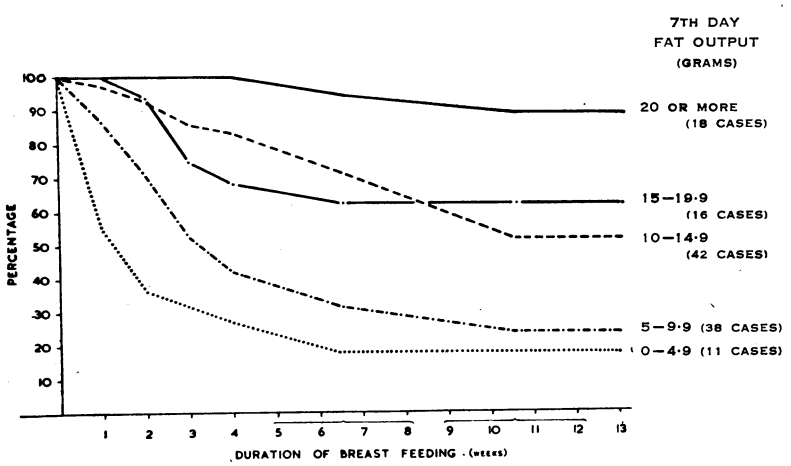

FIG. 2.—The relationship of the fat output in the seventh-day milk to the duration of breast-feeding.

It has been shown in a previous paper that yield and fat content on the seventh day are not related to each other (Hytten, 1954b, V), and Tables I and II demonstrate that both yield and fat content are associated separately with the duration of breast-feeding.

TABLE I.—*Relationship of 7th-Day Milk Yield to Duration of Breast-feeding*

	7th-day Milk Yield (ml.)			
	<300	300–449	450–599	600+
No. of cases	35	41	31	18
Proportion breast-feeding at 13 weeks	26%	46%	58%	78%

TABLE II.—*Relationship of Fat Content of 7th-Day Milk to Duration of Breast-feeding*

	7th-day Milk Fat Content (g./100 ml.)			
	<2·51	2·51–3·25	3·26–4·00	4·01+
No. of cases	28	50	32	15
Proportion breast-feeding at 13 weeks	36%	40%	62%	80%

Discussion

It has been suggested on somewhat slender evidence that breast-fed infants may suffer from deficiencies of certain amino-acids (Clements, 1949; Albanese, 1951); or of some vitamins (Jeans and Marriott, 1947; Naish 1948); but in everyday practice the adequacy of milk as an infant food is judged in terms of its calorie content. The baby who cries or who fails to gain weight because of hunger is the practical problem and the subject of this study.

It is held by some enthusiastic advocates of breast-feeding that almost all women can breast-feed if they want to, with the implication that failure is due to an unwillingness of the mother to make the effort. Jeans and Marriott (1947) make the categorical statement that breast-feeding "is possible at least for the first few months in over 85% of cases," and Illingworth (1953) states: "Another diagnosis which is commonly made by doctor, nurse, or mother—particularly the latter—is that the breast milk is too watery. *For practical purposes this diagnosis is always wrong.* At least, I have not yet seen such a case" (author's italics). In confirmation of this claim, Illingworth quotes the following authors who have published figures showing a very high incidence of breast-feeding. Yung-en Kao (1948) described an incidence of 95% at six months in a series of hospital outpatients at Mukden, and Richardson (1925) an incidence of 92.1% at one month in a district of New York. In neither instance is there any reason to believe that breast milk was necessarily the sole source of nourishment for the child. Read (1949) published a series of 480 women, of whom 98% were discharged from hospital breast-feeding on the twelfth day, but 15% were classified as "breast-feeding—poor," 26% as "breast-feeding—fair," and 46% of the babies had not regained their birth weight. There is no record of the breast-feeding performance after leaving hospital.

A belief in the universal ability to breast-feed is difficult to reconcile with the evidence of deficient lactation presented in this paper. It might be argued that the milk yield can readily be reduced by such emotions as antagonism to, or lack of enthusiasm for, breast-feeding, and to some extent this may be true. However, it has been previously shown (Hytten, 1954c) that the major source of variation in milk yield is in the gross differences which occur in the development of the breasts during pregnancy, and it is unlikely that such well-marked physical changes in the breast are due to emotional factors. Again, the fat content of the milk is closely associated with breast-feeding success, and there is no evidence that the percentage of fat can be altered at will. In fact, the level of fat content has been previously shown (Hytten, 1954b) to be remarkably stable after the first week of lactation.

The evidence strongly suggests, then, that "failure of lactation" is a real phenomenon, and that those women who produce less than 10 g. of fat on the seventh day are very unlikely to be able to breast-feed successfully. This group constitutes one-third of the cases in this series.

Although it is necessary to know the fat content of the milk in order to judge fully the adequacy of lactation, it is clear from Table I that yield alone is of considerable prognostic value. The seventh-day yield, calculated from test weighing the baby and measuring strippings from the breast, is a relatively simple clinical test, and of those women in this series who produced a pint (570 ml.) of milk or more on the seventh day 81% breast-fed for three months at least.

However, although the level of lactation is a major underlying influence in the success of breast-feeding, there are clearly other factors involved. For example, all women secreting more than 15 g. of fat on the seventh day probably had an adequate lactation, and yet 26% of them failed to continue breast-feeding for three months. These factors will be discussed in a future publication.

It has been shown previously (Hytten, 1954b) that such differences as occur in the lactose and protein contents of

the seventh-day milk are due to differences in the speed of maturation, and that in more mature milk the variation in these constituents has practically disappeared. In this study there were no differences in the success of lactation which were associated with the protein content of the seventh-day milk, so that the speed of maturation is apparently of no particular importance in this connexion. That is, milk which is slow to "come in" does not necessarily portend unsuccessful breast-feeding.

The rapidity with which women with poor lactation stop breast-feeding emphasizes the importance of studying human milk composition as early as possible in lactation, if the full range of variation is to be appreciated. Any investigation of human milk secreted after the second or third month of lactation would be carried out on a highly selected population. Those women with poor lactation would, of necessity, have abandoned breast-feeding, and although a considerable variation in milk composition may remain among the rest there will be little or no really poor milk discovered. This may, in part, be the basis for the widely held belief that variations in milk composition are unimportant.

Summary

The success of lactation, judged by the duration of breast-feeding and the weight gain of the baby, is shown for 167 subjects whose milk was analysed on the seventh post-partum day. Both milk yield and fat content were related to the clinical data. The total fat output had a stronger relationship than either.

There was a marked relationship between the seventh-day fat output and the baby's weight gain in hospital.

The breast-feeding history of 148 of these subjects was known until the 13th week. In 23, breast-feeding was terminated for reasons unconnected with the adequacy of lactation. In the remaining 125 there was a marked relationship between fat output on the seventh day and the duration of breast-feeding.

Accurate weights during the first three months of life were known for 83 of the infants, and, although there was a strong relationship between fat output and weight gain during the first month, there was none after this time. This effect is presumably due to the elimination of those infants initially fed on milk of low nutritive value, leaving at the breast only those for whom the milk was at least adequate.

I am grateful to Professor Dugald Baird and the staffs of the Midwifery Department and the Aberdeen Maternity Hospital and to the health visitors of the Maternity and Child Welfare Department for invaluable help; to Professor John Craig, of the Department of Child Health, and Dr. I. Leitch, of the Commonwealth Bureau of Animal Nutrition, Bucksburn, for criticism and advice; and to Mr. J. F. Scott for statistical assistance.

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CARCINOMA OF THE MIDDLE EAR

BY

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This report is concerned with carcinoma arising primarily in the epithelium of the middle-ear cavity or mastoid air cells. The disease is rare. We have been able to find only 120 cases in the literature, and even this figure is only approximate, as the accounts often include cases of growth arising in the external meatus. Risch and Lisa (1938) gave a full account of many previous case reports and a comprehensive bibliography. It is usually impossible to decide clinically whether one is dealing with a carcinoma of the tympanum or of the external meatus, but the former has some distinct features, illustrated by the following six cases.

Case 1

A married woman aged 62 was first seen in July, 1947, complaining of having had right-sided otorrhoea for five months and pain in the right side of the lower jaw for three months. She was found to have an incomplete right facial paralysis of the lower motor neurone type, induration in the inferior portion of the right parotid gland, granulation tissue deep in the meatus, and a blood-stained discharge. Malignant disease was suspected, and was confirmed by biopsy of the aural granulation tissue, which revealed "a well-differentiated squamous-cell carcinoma, almost completely keratinized." It was decided that irradiation should be the first means of treatment, and 8,200 r was given from August 18 to October 9 by teleradium (5-g. unit) and deep *x* rays.

On December 19 the temporal bone was explored through a post-aural incision. As the mastoid process and the middle ear were found to be largely replaced by tumour an extensive excision was performed. The facial nerve, although not identified, was removed with the tumour tissue, as the facial paralysis was later found to be complete. The dura and the temporo-mandibular joint were not involved. The pain disappeared after the operation, and the disabilities resulting from the facial paralysis became the patient's chief concern and were to some extent rectified by a right tarsorrhaphy and a fascial sling. There has been no evidence of recurrence.

Case 2

A man aged 44 was seen for the first time in November, 1951. He had suffered from bilateral otorrhoea for twenty years, but came for advice because of increasing deafness. Both middle ears were extensively damaged, but both were dry. A hearing-aid was prescribed. One month later he developed a right facial paralysis. Examination then showed granulations protruding through a large postero-superior perforation in the right drum. He complained of severe pain in the ear, but there was no mastoid tenderness. A right radical mastoidectomy was performed (post-aural approach) in the belief that this was a case of chronic infection with an acute exacerbation. A good deal of granulation tissue was found in the mastoid process and tympanum, together with much erosion and destruction of bone. The horizontal portion of the facial nerve was exposed. The wound was packed with bipp ribbon gauze